Draft

Risk-Based End State Vision for Lawrence Livermore National Laboratory Livermore Site

United States Department of Energy

Livermore Site Office

Environmental Stewardship Division

Livermore, California 94550

October 2003

Table of Contents

List of Figures

List of Attachments

Acronyms and Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSM	Conceptual Site Model
DOE	U.S. Department of Energy
DTSC	Department of Toxic Substances Control
EM	Environmental Management
FY	Fiscal Year
EPA	U.S. Environmental Protection Agency
LLNL	Lawrence Livermore National Laboratory
MCL	Maximum Contaminant Level
MNA	Monitored natural attenuation
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethylene (perchloroethylene)
RBES	Risk-Based End State
ROD	Record of Decision
RWQCB	California Regional Water Quality Control Board
SVE	Soil vapor extraction
TCE	Trichloroethylene
VOC	Volatile organic compound

Executive Summary

This Risk-Based End State (RBES) Vision for the Lawrence Livermore National Laboratory (LLNL) Livermore Site compares environmental site conditions and remedial strategies between the current and planned future use of the site. The Risk-Based End State Vision focuses on ensuring that the U.S. Department of Energy (DOE) cleanup strategy is driven by risk to human and ecological receptors, rather than compliance with numerous independent, and sometimes contradictory, requirements. DOE recognizes that the End State Vision may not agree with existing site compliance agreements or regulations.

The Current State describes the site conditions and cleanup strategy at the present time. The Risk-Based End State describes anticipated conditions approximately 20 years in the future, and identifies a future cleanup strategy that reflects these conditions and is designed to protect human health and the environment by using sustainable, long-term barriers to prevent exposure to contaminants.

This document includes standardized maps that show the Current State and Risk-Based End State for the physical and surface interface; human and ecological land use; land ownership; demographics; and hazards at regional, site-specific, and site-level scales. Conceptual Site Models show, in diagram form, information regarding the hazards, pathways, receptors, and barriers to exposure (current or planned) between the hazards and the receptors.

Site Background

The primary mission of the Livermore Site is to ensure that the nation's nuclear weapons remain safe, secure, and reliable and to prevent the spread and use of nuclear weapons worldwide. Livermore Site programs include advanced defense technologies, energy, environmental sciences, biosciences, and basic science applied to the enhancement of national security. The Livermore Site is a contributor to the Stockpile Stewardship and Homeland Security programs.

During past Livermore Site operations, volatile organic compounds (VOCs), primarily trichloroethylene (TCE) and perchloroethylene (PCE), tritium, fuel hydrocarbons, and metals were released to the environment. Initial hazardous materials releases occurred in the mid- to late-1940s when the site was the Livermore Naval Air Station. There is also evidence that localized spills, unlined landfills, and leaking tanks and impoundments contributed contaminants to soil and ground water in the post-Navy era. VOCs and metals are present in ground water in concentrations above drinking water standards.

Environmental restoration activities at the Livermore Site are regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The site was added to the CERCLA National Priorities List in 1987. The U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) provide regulatory oversight. DOE is the lead agency for environmental restoration at the Livermore Site.

A Record of Decision (ROD) for the Livermore Site was signed in 1992 that specified that ground water would be remediated to Maximum Contaminant Levels (MCLs) both onsite and offsite.

The selected remedies for the Livermore Site cleanup consist of extracting and treating contaminated ground water and soil vapor. The Livermore Site cleanup has been expedited by implementing an Engineered Plume Collapse strategy, “smart” pump and treat, contaminant source isolation, portable treatment unit technology, and innovative remediation technologies such as catalytic reductive dehalogenation. Significant progress has been made in reducing the extent and concentrations of the ground water VOC plume that extended offsite to the west of the Livermore Site, and in controlling and reducing the concentrations and mass of onsite VOCs. The two CERCLA Five-Year Reviews have concluded that the existing remediation network continues to function as intended and is protecting human health and the environment.

Risk-Based End State Vision

For this Risk-Based End State Vision, the individual contaminant release sites at the Livermore Site have been grouped into a single Hazard Area. This document evaluates a number of factors relevant to the implementation of a Risk-Based End State at the Livermore Site, including:

- Physical and Surface Interface.
- Human and Ecological Land Use.
- Legal Ownership.
- Demographics.
- Primary and Secondary Contaminant Sources.
- Release, Transport, and Exposure Mechanisms.
- Temporary Barriers or Controls.
- Remediation, Mitigation, and Other Intervention.

In general, there are few differences between the Current State and Risk-Based End State exposure scenarios because the Livermore Site is assumed to remain under DOE control for the foreseeable future and no major changes in offsite land use are anticipated. No significant changes in contaminant release, transport, and exposure mechanisms or in receptors were identified between the Current State and Risk-Based End State.

The major differences between the Current State and Risk-Based End State occur in the onsite ground water cleanup approach. The specific remedial actions (barriers to exposure) now being implemented under the Current State and those that would be conducted under a Risk-Based End State are:

Current State

- Continue ground water extraction until the MCL ground water cleanup standards are achieved both onsite and offsite. The point of compliance is the impacted ground water body.
- Continue soil vapor extraction until contaminants in the vadose (unsaturated) zone have been reduced to concentrations that no longer impact ground water at concentrations exceeding MCLs.
- Maintain institutional controls to restrict site access and facility/land use in contaminated areas during remediation.

Risk-Based End State

- The Risk-Based End State Vision assumes that the ground water remediation being conducted under the Current State exposure scenario has, at some point in the future: (1) achieved the MCL cleanup standards offsite, and (2) reduced onsite contaminant mass and concentration such that remaining onsite contaminants no longer migrate offsite at concentrations exceeding MCLs. All remaining ground water contamination would be addressed through monitored natural attenuation. No further ground water extraction would be performed. The point of compliance would be the site boundary.
- It is assumed that soil vapor extraction conducted under the Current State scenario will have reduced vadose zone contaminant concentrations to levels protective of ground water. No further soil vapor extraction would be performed.
- Maintain long-term onsite institutional controls to manage exposure for the foreseeable future.

Variances

There are two primary obstacles to implementing the Risk-Based End State Vision described in this document:

1. **Ground Water Compliance Point -** The Risk-Based End State Vision assumes that the site boundary is the compliance point for contaminants in ground water. This is not consistent with State of California ground water regulations and policies that consider the impacted ground water body to be the point of compliance.
2. **Ability to Achieve Risk-Based Concentrations -** It is unlikely that the ground water extraction being implemented under the Current State can adequately reduce contaminant concentrations to levels consistent with the implementation of a Risk-Based End State in the 20-year timeframe considered in this Vision document.

These obstacles are discussed in more detail in the Variance Report attached to this Risk-Based End State Vision. It is expected that these Variances will be refined through discussions with the regulatory agencies, adjacent landowners, and other stakeholders during the development of the Risk-Based End State Vision for the Livermore Site.

1. Introduction

This Risk-Based End State (RBES) Vision for the Lawrence Livermore National Laboratory (LLNL) Livermore Site was prepared in response to one of the Corporate Projects ("A Cleanup Program Driven by Risk-Based End States") established by the U.S. Department of Energy (DOE) Office of Environmental Management (EM) in response to the EM Top-to-Bottom Review completed in 2002. DOE sites are directed to create Risk-Based End State Visions for submission to the Assistant Secretary for Environmental Management. This Livermore Site Risk-Based End State Vision was prepared according to the September 2003 *Guidance for Developing a Risk-Based End State Vision,* and to comply with DOE Policy 455.1, *Use of Risk-Based End States*. One of the primary goals of the Risk-Based End State Corporate Project is to transform the varying applications and/or versions of essential management tools (e.g., land-use maps, conceptual site models) developed at individual DOE sites into a single unified approach.

Risk-Based End States are representations of site conditions and associated information that reflect the planned use of property approximately 20 years in the future. The Risk-Based End State Vision focuses on ensuring that the U.S. Department of Energy (DOE) cleanup strategy is driven by risk to human and ecological receptors, rather than compliance with numerous independent, and sometimes contradictory, requirements. DOE recognizes that the End State Vision may not agree with existing site compliance agreements or regulations. The Risk-Based End State approach attempts to gain a common acceptance of the site-wide post-remediation future. After Risk-Based End States are developed, sites will re-evaluate their cleanup activities and strategic approaches to determine if it is appropriate to change site baseline documents and renegotiate agreements with the regulatory agencies.

Primary sources of information used to prepare this document include:

- Draft Site Wide Environmental Impact Statement for the Continued Operation of LLNL.
- Alameda County Planning Department.
- City of Livermore.
- Livermore Site Baseline.
- Record of Decision for the Livermore Site.

1.1. Organization

This document presents a series of standardized maps that show the Current State and Risk-Based End State for the physical and surface interface; human and ecological land use; land ownership; demographics; and hazards at regional, site-specific, and site-level scales. Chapter 2 of this document presents regional-scale maps of the physical and surface interface, and human and ecological land use. Chapter 3 presents site-specific maps that show the physical and surface interface, human and ecological land use, legal ownership and demographics. Chapter 4 presents Conceptual Site Models and Hazard Maps. The text discusses features not apparent on the maps or that supplement the maps and differences between the Current State and Risk-Based End State maps and Conceptual Site Models.

1.2. Livermore Site Mission

The primary mission of the Livermore Site is to ensure that the nation's nuclear weapons remain safe, secure, and reliable and to prevent the spread and use of nuclear weapons worldwide. Livermore Site programs include advanced defense technologies, energy, environmental sciences, biosciences, and basic science applied to the enhancement of national security. The Livermore Site is a contributor to the Stockpile Stewardship and Homeland Security programs. Statements from Congressional representatives and the Administration regarding the importance of the National Laboratories to the nation's continued scientific and defense interests indicate that the Livermore Site will continue to exist and serve this mission for the foreseeable future.

1.3. Status of the Livermore Site Cleanup Program

During past Livermore Site operations, volatile organic compounds (VOCs), primarily trichloroethylene (TCE) and perchloroethylene (PCE), tritium, fuel hydrocarbons, and metals were released to the environment. Initial hazardous materials releases occurred in the mid- to late-1940s when the site was the Livermore Naval Air Station. There is also evidence that localized spills, unlined landfills, and leaking tanks and impoundments contributed contaminants to soil and ground water in the post-Navy era. VOCs and metals are present in ground water in concentrations above drinking water standards. It is currently estimated that about 3 billion gallons of ground water to a depth of about 200 feet is contaminated.

Environmental restoration activities at the Livermore Site are regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The site was added to the CERCLA National Priorities List in 1987. The U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) provide regulatory oversight. DOE is the lead agency for environmental restoration at the Livermore Site.

A Record of Decision (ROD) for the Livermore Site was signed in 1992. The cleanup standards established in the ROD specify that ground water will be remediated to Maximum Contaminant Levels (MCLs) both onsite and offsite. Four Explanations of Significant Differences have been prepared to modify the remedies selected in the ROD. Two Five-Year Reviews on the progress of the cleanup have been prepared since the ROD was signed.

The selected remedies for the Livermore Site cleanup consist of extracting and treating contaminated ground water and soil vapor. The Livermore Site cleanup has been expedited by implementing an Engineered Plume Collapse strategy, "smart" pump and treat, contaminant source isolation, portable treatment unit technology, and innovative remediation technologies such as catalytic reductive dehalogenation. Significant progress has been made in reducing the extent and concentrations of the ground water VOC plume that extended offsite to the west of the Livermore Site, and in controlling and reducing the concentrations and mass of onsite VOCs. The two Five-Year Reviews have concluded that the existing remediation network continues to function as intended and is protecting human health and the environment.

As specified in the ROD, the objective of the Livermore Site cleanup is to achieve a rapid, efficient, and cost-effective remediation within budgetary constraints and in compliance with regulatory requirements. The remediation strategy for the Livermore Site employs a prioritized approach with an emphasis on risk reduction. The overall cleanup objectives are to protect human health and the environment, control and prevent further offsite plume migration, and to clean up and restore the beneficial use of ground water. In agreement with the regulatory agencies and the neighboring community, the following priorities have been established for the Livermore Site in the 1994 Consensus Statement:

- Control the western ground water VOC plume boundary, prevent further offsite plume migration, and clean up offsite plumes. Prevent contamination of water-supply wells and associated risk to human health and loss of beneficial uses of ground water.
- Control the southern ground water plume boundary, prevent further offsite plume migration, and clean up offsite plumes.
- Control and clean up internal contaminant sources.

Milestones for cleanup the Livermore Site are established in conjunction with the overseeing regulatory agencies with input from the local community, and are specified in an attachment to the Livermore Site Remedial Action Implementation Plan.

2. Risk-Based End State Vision: Regional Context

2.1. Physical and Surface Interface

Regional-scale Current State and Risk-Based End State physical and surface interface maps are presented in Figures 2.1a and 2.1b, respectively. The Livermore Site is located immediately east of the City of Livermore and is accessible by major freeways and roads. The 821-acre site slopes very gently to the northwest and is enclosed by fencing patrolled by LLNL security staff. Two active fault zones, the Greenville Fault Zone to the east and the Las Positas Fault Zone to the south, are located within one mile of the Livermore Site. Wind turbines for generating electricity are located in the hills east and northeast of the Livermore Site.

There are no differences between the Current State and Risk-Based End State maps.

2.2. Human and Ecological Land Use

Figures 2.2a and 2.2b show the regional human and ecological land use. West of the Livermore Site is a combination of residential and commercial land associated with the City of Livermore, with some agricultural land interspersed. The map indicates agricultural land use north of the site, but much of this area is being developed with light industrial and commercial buildings. Non-agricultural vegetated grasslands (primarily private cattle ranches) are present to the east and southeast. Sandia National Laboratories (Livermore) is located immediately south of the site, with agricultural and non-agricultural lands further south.

No critical ecological habitats currently exist at the Livermore Site. The site was designated as critical habit for the threatened California red-legged frog until 2002. Areas containing the elements of a wetland are present at the Livermore Site, including two arroyos, one artificial lake, and several drainage ditches. Although these areas have not been officially designated as wetlands, LLNL manages them as such. The white-tailed kite, a California State fully-protected raptor, also occupies the Livermore Site during nesting periods. LLNL biologists use Best Management Practices to control unnecessary activities near the nesting sites to enhance the probability of successful hatches.

There are no differences between the Current State and Risk-Based End State maps.

3. Site-Specific Risk-Based End State Description

3.1. Physical and Surface Interface

Site-specific Current State and Risk-Based End State physical and surface interface maps are presented as Figures 3.1a and 3.1b, respectively. Two intermittent streams, Arroyo Seco and Arroyo Las Positas, are present in the vicinity of the Livermore Site. Northwest-flowing Arroyo Seco traverses the southwest corner of the site. This arroyo typically contains water only during and after winter storms, but currently three facilities discharge treated ground water into the Arroyo and causes very localized flow. West-flowing Arroyo Las Positas approaches the site from the east where it has been diverted to flow along the eastern and northern site boundaries. Arroyo Las Positas flows perennially along the northern site boundary due to surface discharges of treated ground water from the Livermore Site. The South Bay Aqueduct is present southeast and east of the site, and the Patterson filtration reservoir is located about 0.5 miles east-northeast of the site. Two railroad tracks are present within one mile of the northern site boundary.

Figure 3.1a shows the extent of ground water and soil contamination and the locations of the current Livermore Site treatment facilities. The nearest commercial or municipal potable water supply wells are located about 1.5 miles west of the western leading edge of the ground water VOC plume. Other wells used to supply irrigation and drinking water to ranches and homes are located immediately southeast and west-southwest of the site. In addition, wells supplying irrigation water for the Wente vineyards are located about one half a mile west-southwest of the Livermore Site.

There are no differences between the Current State and Risk-Based End State maps.

3.2. Human and Ecological Land Use

Figures 3.2a and 3.2b, respectively, show the site-specific Current State and Risk-Based End State human and ecological land use within and adjacent to the Livermore Site. Onsite land uses include offices, laboratory buildings, support facilities, roadways, parking areas, and landscaping. A security buffer zone 400 to 500 feet wide is present west and north of the site. Figure 3.2a shows that City of Livermore residential land consisting of single-family homes adjoins the site to the west and southwest. An athletic field park is located immediately northwest of the site. Figure 3.2a also shows commercial light industrial land use north and northwest of the site. The land northeast and southeast of the Livermore Site is predominantly grass-covered ranch land that is used largely for cattle grazing. A small oil field, the Livermore Oil Field, is located just south of Patterson Pass Road about one half mile east of the Livermore Site. Sandia National Laboratories (Livermore) is located immediately south of the Livermore Site. Relatively small parcels of commercial land are present southwest and east of the site, including a Western Area Power Administration substation at the southeast corner of Greenville and Patterson Pass Roads. Small residential parcels exist east of the site.

There are no differences between the Current State and Risk-Based End State maps.

3.3. Site Context Legal Ownership

Current State and Risk-Based End State ownership maps are presented as Figures 3.3a and 3.3b, respectively. As shown on Figure 3.3a, the Livermore Site and the Sandia National Laboratories property to the south are owned by the Federal government (U.S. Department of Energy). All the land in the immediate vicinity to the north, east, and west of the Livermore Site is privately owned.

There are no differences between the Current State and Risk-Based End State maps.

3.4. Site Context Demographics

Figures 3.4a and 3.4b show the population density in the Livermore Site vicinity for the Current State and Risk-Based End State. As shown on Figure 3.4a, higher population densities (500 – 5,000 people per square mile) near the Livermore Site are limited to the residential areas immediately to the west. The area north, east, and south of the site is characterized by low population density, less than 150 people per square mile. Because there are no available population density projections, there are no differences between the Current State and Risk-Based End State maps.

4. Hazard Specific Discussion

Initial hazardous materials releases occurred at the Livermore Site in the mid- to late-1940s when the site was the Livermore Naval Air Station. There is also evidence that localized spills, unlined landfills, and leaking tanks and impoundments released contaminants to the ground water and unsaturated sediments in the post-Navy era.

Contaminants in ground water beneath the site at concentrations above drinking water standards are:

- VOCs.
- Fuel hydrocarbons.
- Chromium.
- Tritium.

4.1. Hazard Specific Discussion for the LLNL Livermore Site

The Livermore Site is defined as a single Site-wide Hazard Area due to the similarities in:

- **Release Mechanism -** The releases are predominantly point source, resulting from discharges to the ground surface or shallow soil.
- **Primary and Secondary Sources -** The environmental media affected are ambient air, soil, sediment, and ground water.
- **Release, Transport, and Exposure Mechanisms -** These factors are similar for all release areas at the Livermore Site, and include subsurface flow and transport, and ingestion, inhalation, and dermal exposure pathways.
- **Extent of Contamination -** Contamination from release areas at the Livermore Site is generally contained within the site boundary. The extent of offsite contamination (south and southwest of the site) has been reduced by aggressive remedial actions.
- **Temporary Barriers or Controls -** All release areas at the Livermore Site share similar controls, such as measures to restrict access to contaminated areas.
- **Remediation, Mitigation, and Other Interventions -** Remediation is underway at most of the release areas at the Livermore Site. Remedial technologies include soil vapor and/or ground water extraction and treatment.
- **Future Land Use -** All release areas at the Livermore Site are located within the boundary of the site. It is assumed that DOE will maintain control of the site for the foreseeable future.

4.1.1. Current State

Section 4.1.1 presents the Current State exposure scenario for the Livermore Site. The Current State describes conditions, land use, and remedial actions in place at the present time.

The following characteristics of the Livermore Site are included in the Current State exposure scenario:

- Individual contaminant release areas.

- Primary and secondary sources of contaminants.
- Release, transport, and exposure mechanisms, including human and ecological receptors.
- Temporary barriers or controls.
- Remediation, mitigation, or other intervention.

The Current State Site-wide Hazard Map is presented as Figure 4.0a, and the Current State Site-wide Conceptual Site Model as Figure 4.0a2.

4.1.1.1. Hazard Area Description

During past Livermore Site operations, VOCs, tritium, fuel hydrocarbons, and metals were released to the environment. Initial hazardous materials releases occurred in the mid- to late-1940s when the site was the Livermore Naval Air Station. There is also evidence that localized spills, unlined landfills, and leaking tanks and impoundments contributed contaminants to soil and ground water in the post-Navy era. VOCs and metals are present in ground water in concentrations above drinking water standards. It is currently estimated that about 3 billion gallons of ground water to a depth of about 200 feet is contaminated.

The selected remedies for the Livermore Site cleanup consist of extracting and treating contaminated ground water and soil vapor. The Livermore Site cleanup has been expedited by implementing Engineered Plume Collapse, “smart” pump and treat, contaminant source isolation, portable treatment unit technology and innovative remediation technologies such as catalytic reductive dehalogenation. Significant progress has been made in reducing the extent and concentrations of the ground water VOC plume that extended offsite to the west of the Livermore Site, and in controlling and reducing the concentrations and mass of onsite VOCs. The two Five-Year Reviews have concluded that the existing remediation network continues to function as intended and is protecting human health and the environment.

Cleanup activities thus far have established hydraulic control of the western and southern margins of the ground water contaminant plumes and are preventing further offsite migration. In fact, the extent of ground water contamination west of the Livermore Site has been significantly reduced by ground water extraction and treatment over the last 14 years. Numerous soil vapor and/or ground water extraction and treatment systems are currently operating at the Livermore Site.

4.1.1.2. Primary and Secondary Sources

Primary sources are locations where contaminants were produced, deposited, released, or disposed. The primary sources at the Livermore Site include:

- Surface spills.
- Piping and underground storage tank leaks.
- Disposal pits.
- Landfills.
- Evaporation ponds.
- Storm drains.

Secondary sources are environmental media to which contaminants have migrated. Secondary sources include:

- Vadose (unsaturated) zone soil and sediment.
- Ground water.

4.1.1.3. Release, Transport, and Exposure Mechanisms

The Site-wide Current State Conceptual Site Model diagram is presented as Figure 4.0a2. On all Conceptual Site Model diagrams, active pathways are shown as solid lines, blocked pathways are shown as dashed lines, and incomplete pathways are shown as dotted lines. Barriers are shown as heavy vertical or horizontal lines across the exposure pathway they break. The barriers are not equal in their ability to block an exposure pathway. Multiple barriers may be required to assure sustainable protection for current and future receptors.

The contaminant release, transport, and exposure mechanisms under the Current State exposure scenario are described below. Receptors are also identified.

Release Mechanisms

Release mechanisms are the manner in which contaminants migrate from a primary source to an environmental medium (secondary source). The only release mechanism at the Livermore Site is leakage or discharge of contaminants to surface soil or the vadose zone.

Volatilization of contaminants directly from the released contaminant is not applicable because contaminants have already migrated into environmental media and no active sources remain.

Transport Mechanisms

Transport mechanisms describe the migration of contaminants between environmental media. The only potential transport mechanism is infiltration of contaminants from the vadose zone to ground water.

The following transport mechanisms are not applicable:

- **Volatilization of contaminants from surface soil or the vadose zone to ambient indoor and outdoor air -** There are no areas where unacceptable risk or hazard has been identified for this exposure pathway.
- **Resuspension of contaminated soil particles to outdoor ambient air -** There are no areas where unacceptable risk or hazard has been identified for this exposure pathway.
- **Outflow from ground water to surface water -** There is no outflow of ground water to surface water in the vicinity of the Livermore Site.
- **Transport of contaminants by runoff from surface soil or the vadose zone to surface water -** There are no areas where unacceptable risk or hazard has been identified for this exposure pathway.
- **Transport of contaminants by recharge from surface water to ground water -** There are no contaminated surface water bodies at the Livermore Site.

Exposure Mechanisms and Receptors

Exposure mechanisms describe how contaminants move from contaminated environmental media to human or ecological receptors. Receptors are human or ecological species that are potentially exposed to, or adversely affected by, contaminants. Exposure mechanisms and receptors at the Livermore Site are:

- **Contact with contaminants in surface soil or the vadose zone -** This includes dermal contact and incidental ingestion by onsite workers. No unacceptable risk or hazard has been identified.
- **Offsite residential use of ground water -** This pathway includes dermal contact, ingestion, and inhalation by offsite residents. Unacceptable risks were identified at hypothetical water-supply wells that could be installed at the site boundary. However, existing regulations preclude installation of water-supply wells in contaminated areas.
- **Offsite agricultural use of ground water -** This pathway includes dermal contact, ingestion, and inhalation by offsite human receptors. No unacceptable risk or hazard has been identified for this exposure pathway.

The following exposure mechanisms are not applicable:

- **Dispersion of volatile contaminants or resuspended particulates in ambient air -** This includes inhalation by onsite industrial (site) workers. All known remaining contamination in surface or near-surface soil at the Livermore Site is at such low concentrations that this exposure pathway is insignificant.
- **Uptake of contaminants by plants -** The receptor for this pathway is ingestion of vegetation by animals onsite. No unacceptable ecological hazard for this pathway has been identified.
- **Onsite industrial use of ground water -** This pathway includes dermal contact, ingestion, and inhalation by onsite human receptors. There is no industrial use of untreated ground water at the Livermore Site.
- **Onsite contact with surface water -** This pathway includes dermal contact, incidental ingestion, and inhalation by onsite workers. No unacceptable risk or hazard has been identified for this exposure pathway.
- **Offsite contact or use of surface water -** There are no contaminated offsite surface water bodies near the Livermore Site, nor do these water bodies have the potential to become contaminated.

4.1.1.4. Temporary Barriers or Controls

Temporary controls have been implemented at the Livermore Site, including measures to prevent unacceptable risk to onsite workers engaged in activities in which they may be exposed to contaminated soil, such as during construction. These controls are implemented through existing worker health and safety plans.

4.1.1.5. Remediation, Mitigation, and Other Intervention

A number of remedial actions have been implemented at the Livermore Site, or are scheduled to be in place over the next several years. These actions function as barriers to prevent or mitigate human or ecological exposure to contaminants. The barriers are numbered sequentially, beginning with the Current State and continuing through the Risk-Based End State. The Current State exposure barriers are:

<u>Barrier 1 - Soil Vapor Extraction</u>

Soil vapor extraction has been implemented at the Livermore Site to protect ground water from potential or further degradation due to downward migration of contaminants from the vadose zone. Protection of ground water leads to mitigation of risk to onsite and offsite receptors through a ground water exposure pathway.

<u>Barrier 2 - Ground Water Extraction</u>

Ground water extraction has been implemented by installing numerous extraction well fields and associated ground water treatment facilities at the Livermore Site. Specifically, removing contaminants from ground water by extraction reduces risk due to:

- Dermal contact, ingestion, and inhalation by offsite human (residential and agricultural).
- Dermal contact, ingestion, and inhalation by onsite human (industrial) receptors.

Cleanup standards for ground water at the Livermore Site are MCLs.

<u>Barrier 3 - Institutional Controls</u>

The primary institutional control in place at the Livermore Site is site access restriction, enforced through fencing and security guards. A badge is required to gain entry to the site.

4.1.2. Risk-Based End State

Section 4.1.2 presents the Risk-Based End State exposure scenario for the Livermore Site. The Risk-Based End State exposure scenario is assumed to represent conditions approximately 20 years in the future.

Although the organization of the Risk-Based End State exposure scenario parallels that previously presented for the Current State (Section 4.1.1), emphasis is placed on the differences between the Current State and Risk-Based End State, focusing on identifying sustainable mechanisms for addressing exposure pathways.

The Site-wide Hazard Map for the Risk-Based End State exposure scenario is presented as Figure 4.0b, and the Risk-Based End State Conceptual Site Model as Figure 4.0b2.

4.1.2.1. Hazard Area Description

It is assumed that no additional contaminant release areas are identified at the Livermore Site.

4.1.2.2. Primary and Secondary Sources

It is assumed that primary and secondary contaminant sources under the Risk-Based End State exposure scenario are unchanged from those described in the Current State exposure scenario.

4.1.2.3. Release, Transport, and Exposure Mechanisms

It is assumed that release, transport, and exposure mechanisms under the Risk-Based End State exposure scenario are unchanged from those described in the Current State exposure scenario.

Since the Livermore Site has a continuing DOE mission and no significant changes to offsite land use are anticipated, the receptors are assumed to be identical to those described under the Current State exposure scenario.

4.1.2.4. Temporary Barriers or Controls

It is assumed that the temporary controls described under the Current State exposure scenario will be unchanged. These controls exist primarily to protect workers during construction activities.

4.1.2.5. Remediation, Mitigation, and Other Intervention

The key assumptions relevant to identifying potential long-term, sustainable barriers for the Risk-Based End State exposure scenario are:

- Ground water remediation being conducted under the Current State exposure scenario has, at some point in the future: (1) achieved the MCL cleanup standards offsite, and (2) reduced onsite contaminant mass and concentration such that remaining onsite contaminants no longer migrate offsite at concentrations exceeding MCLs. All remaining ground water contamination would be addressed through monitored natural attenuation. No further ground water extraction would be performed. The point of compliance would be the site boundary.
- The State of California agrees that onsite Risk-Based ground water standards are acceptable, rather than reaching MCLs as specified in the ROD.
- Soil vapor extraction conducted under the Current State scenario will have reduced vadose zone contaminant concentrations to levels protective of ground water. No further soil vapor extraction would be performed.
- The stakeholders agree that long-term institutional controls are an acceptable risk management measure in lieu of active remediation to levels consistent with unrestricted land use.
- LLNL Livermore Site remains under DOE control and has a continuing mission.
- There are no unanticipated changes to offsite land use or demographics.

The Risk-Based End State exposure barriers are described below. The barriers are numbered sequentially, beginning with the Current State and continuing through the Risk-Based End State.

<u>Barrier 4 - Monitored Natural Attenuation</u>

All remaining ground water contamination would be addressed through monitored natural attenuation.

<u>Barrier 5 - Institutional Controls</u>

Long-term institutional controls would be maintained under the Risk-Based End State exposure scenario to:

- Restrict access to the Livermore Site.
- Control exposure of onsite workers to contaminants in soil (dermal contact and incidental ingestion) by restricting access to specific areas and monitoring potential exposure during construction activities.

Figures

Figure 2.1a Regional Physical and Surface Interface - Current State

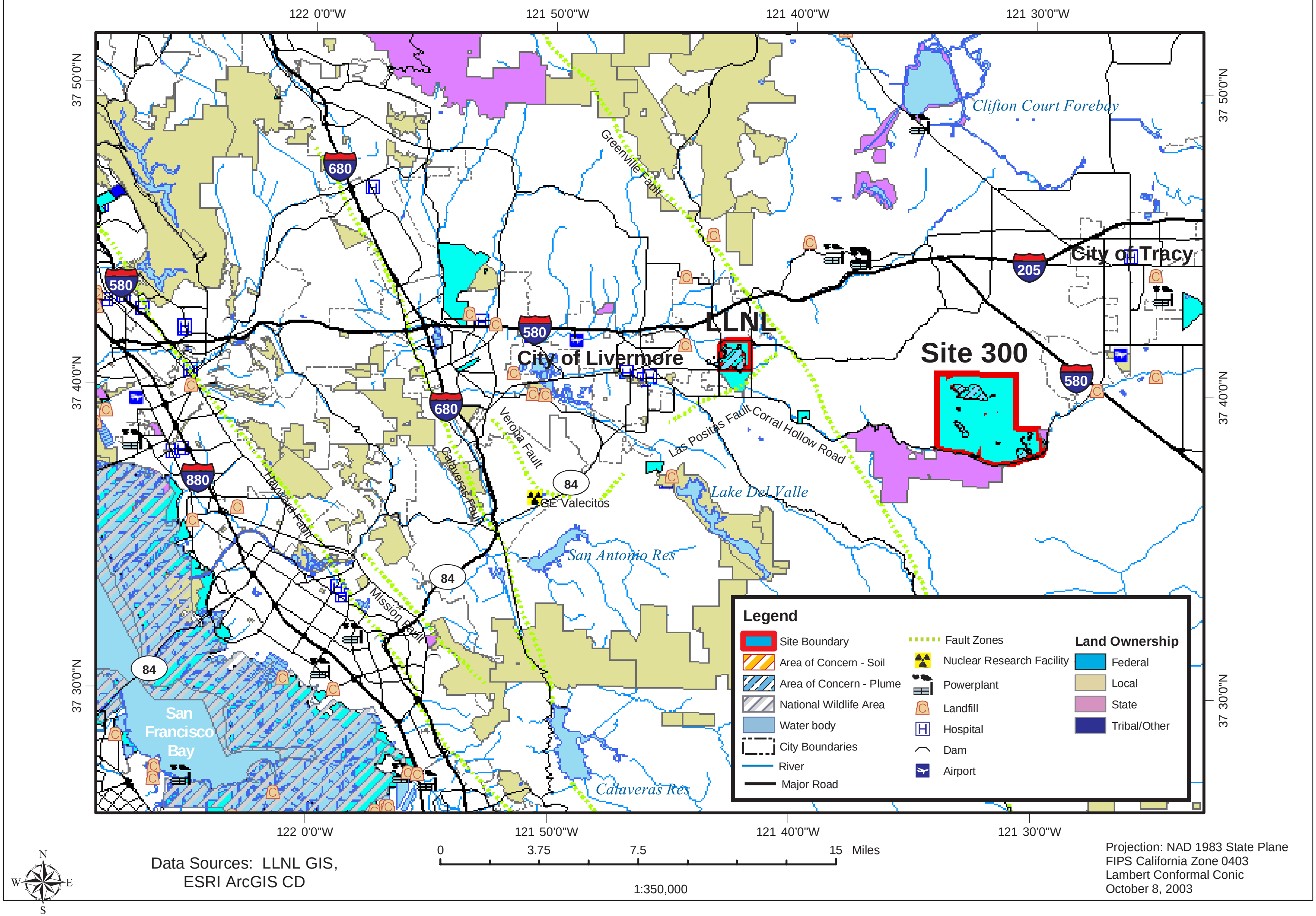
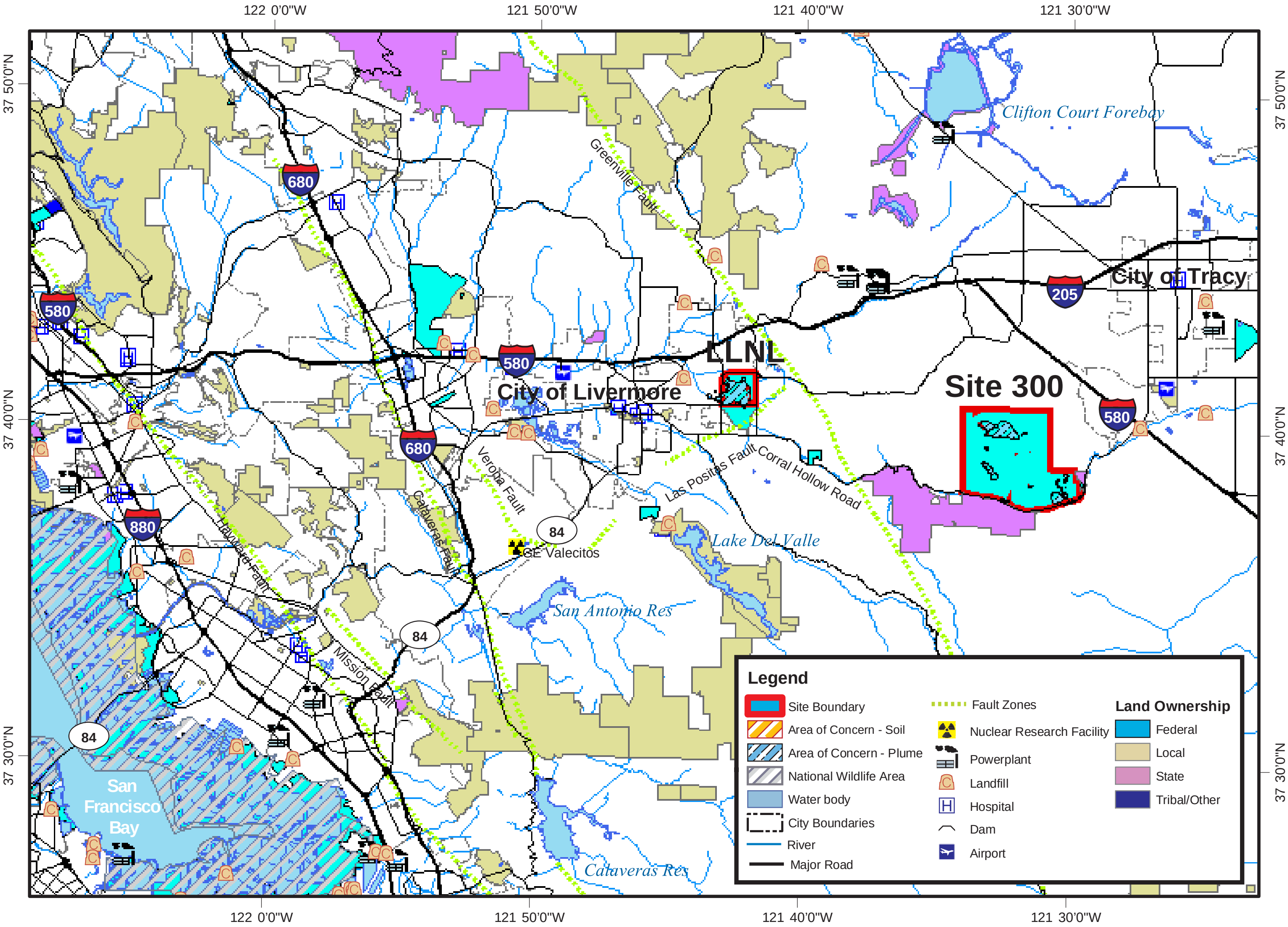


Figure 2.1b Regional Physical and Surface Interface - RBES



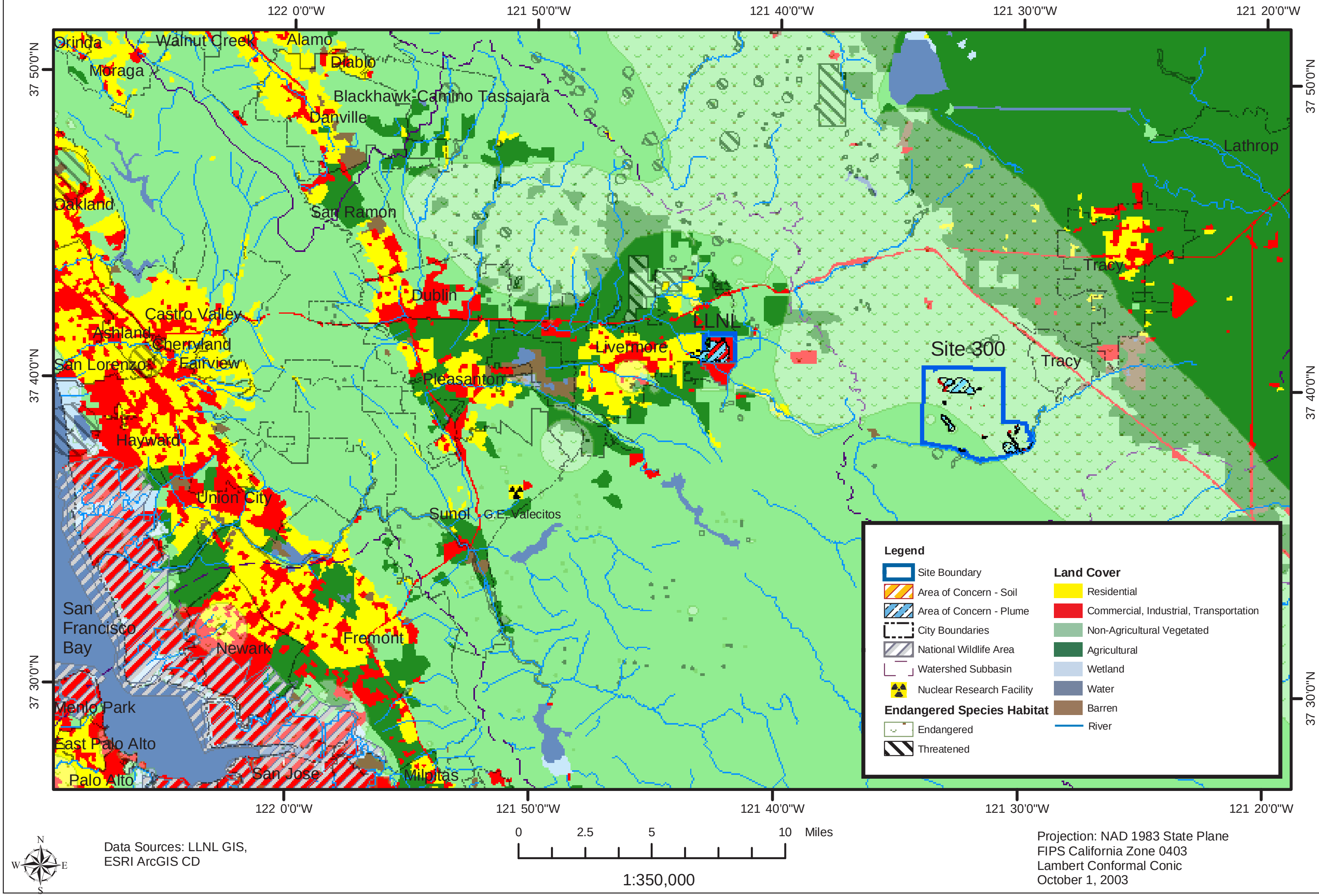
Data Sources: LLNL GIS, ESRI ArcGIS CD

0 3.75 7.5 15 Miles

1:350,000

Projection: NAD 1983 State Plane
FIPS California Zone 0403
Lambert Conformal Conic
October 8, 2003

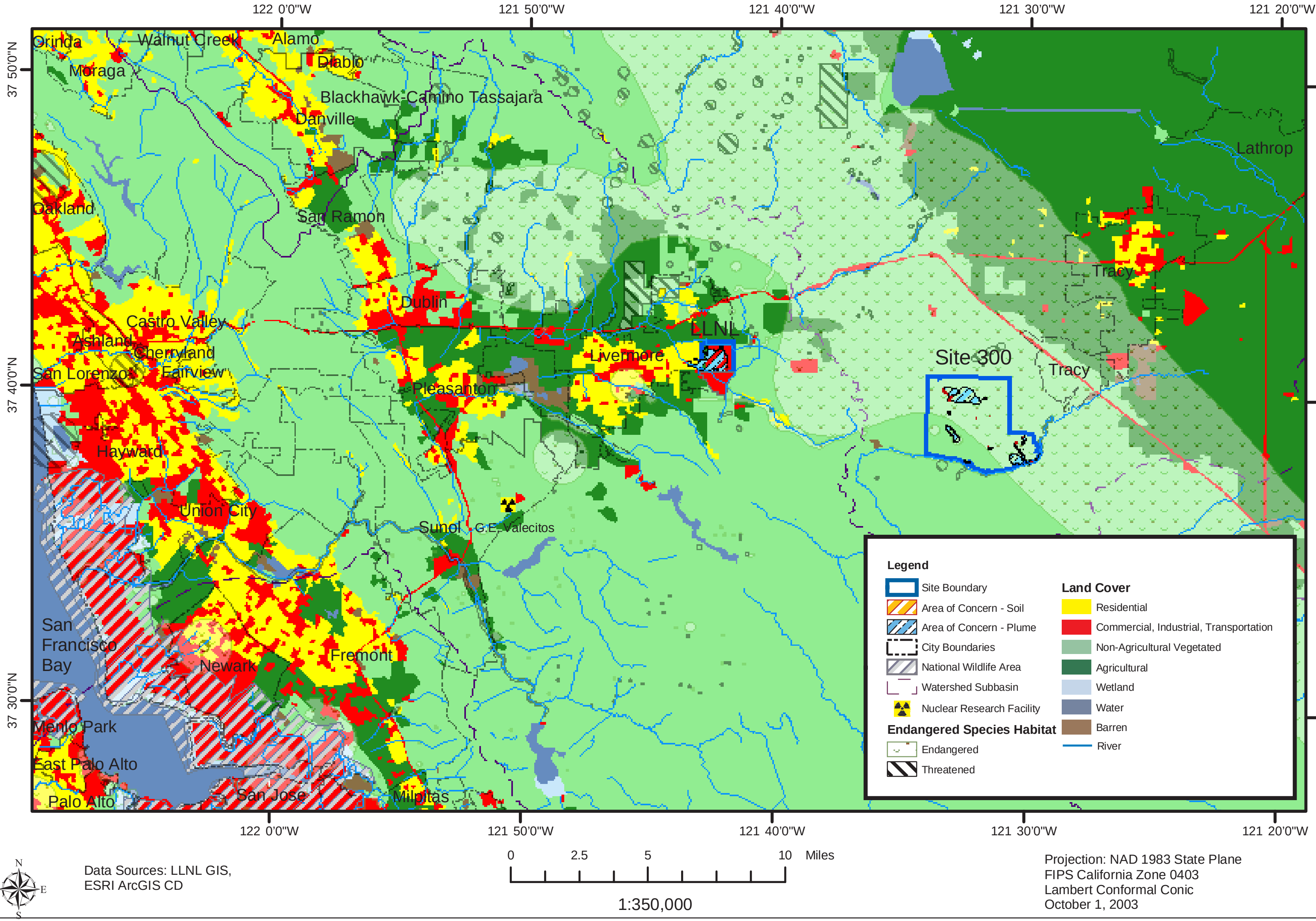
Figure 2.2a. Regional Human and Ecological Land Use - Current State



Data Sources: LLNL GIS,
ESRI ArcGIS CD

Projection: NAD 1983 State Plane
FIPS California Zone 0403
Lambert Conformal Conic
October 1, 2003

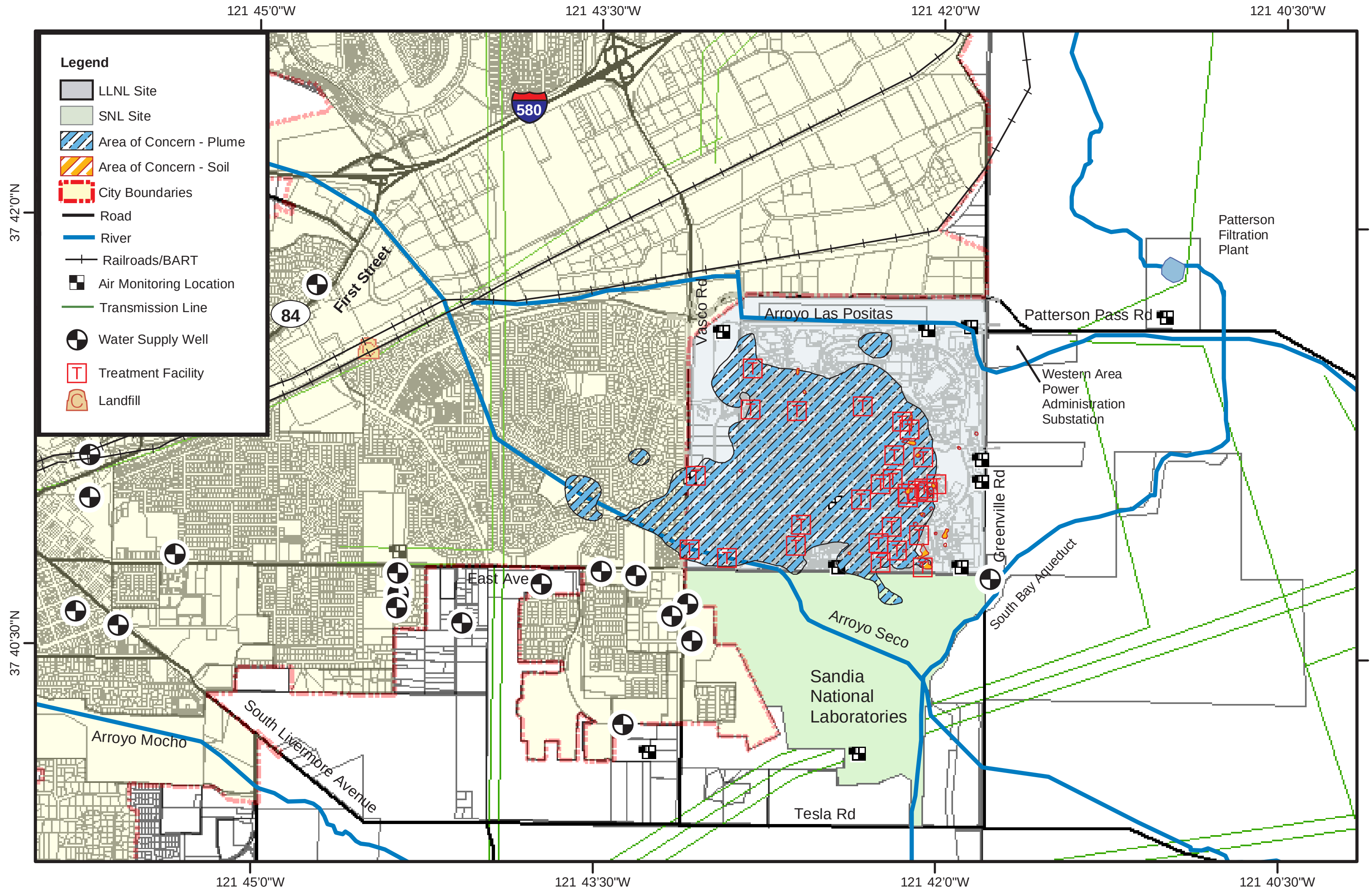
Figure 2.2b. Regional Human and Ecological Land Use - RBES



Data Sources: LLNL GIS, ESRI ArcGIS CD

Projection: NAD 1983 State Plane
FIPS California Zone 0403
Lambert Conformal Conic
October 1, 2003

Figure 3.1a. Site Physical and Surface Interface - Current State



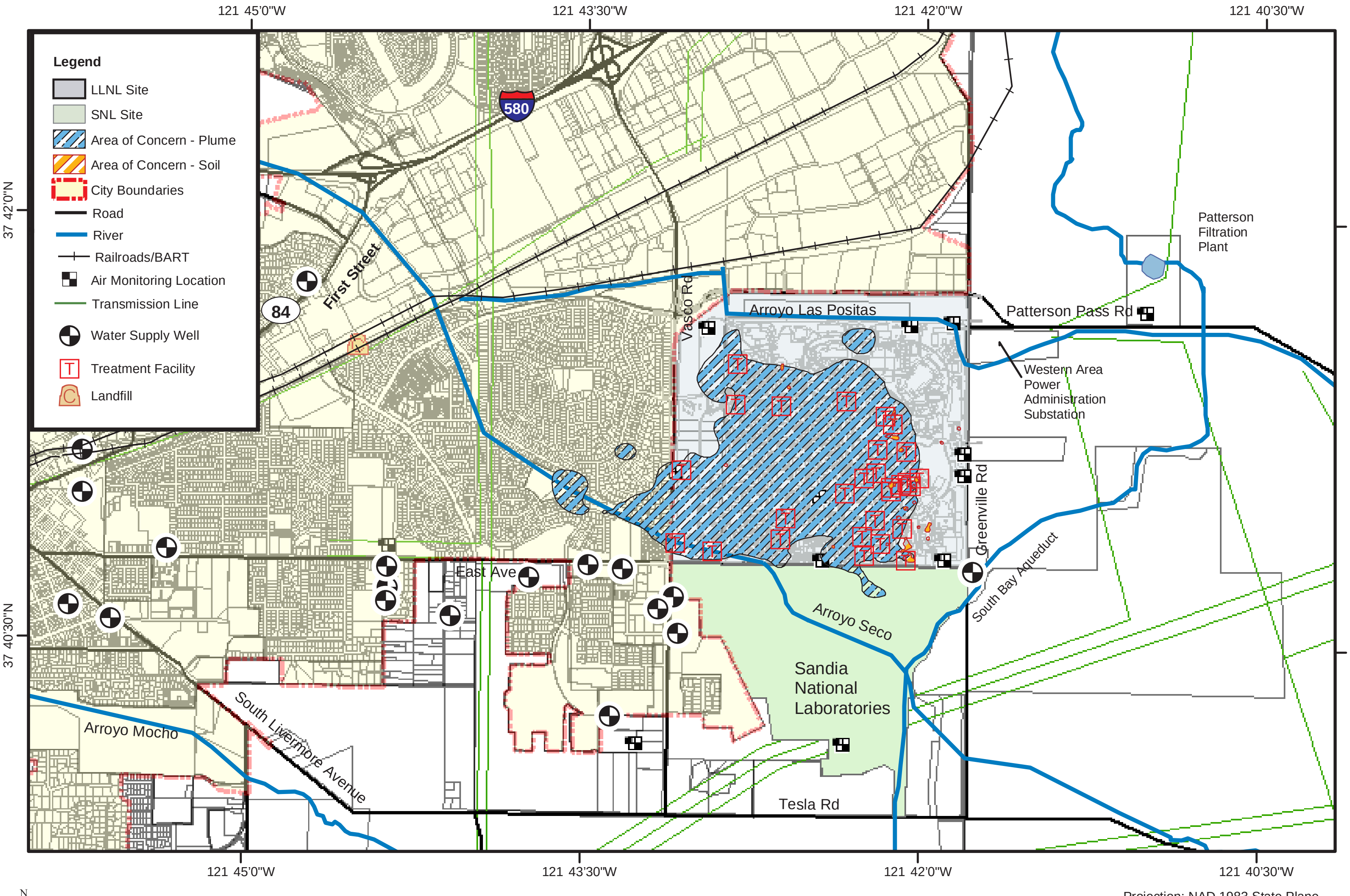
Data Sources: LLNL GIS,
ESRI ArcGIS CD

0 0.25 0.5 1 Miles

1:40,000

Projection: NAD 1983 State Plane
FIPS California Zone 0403
Lambert Conformal Conic
October 1, 2003

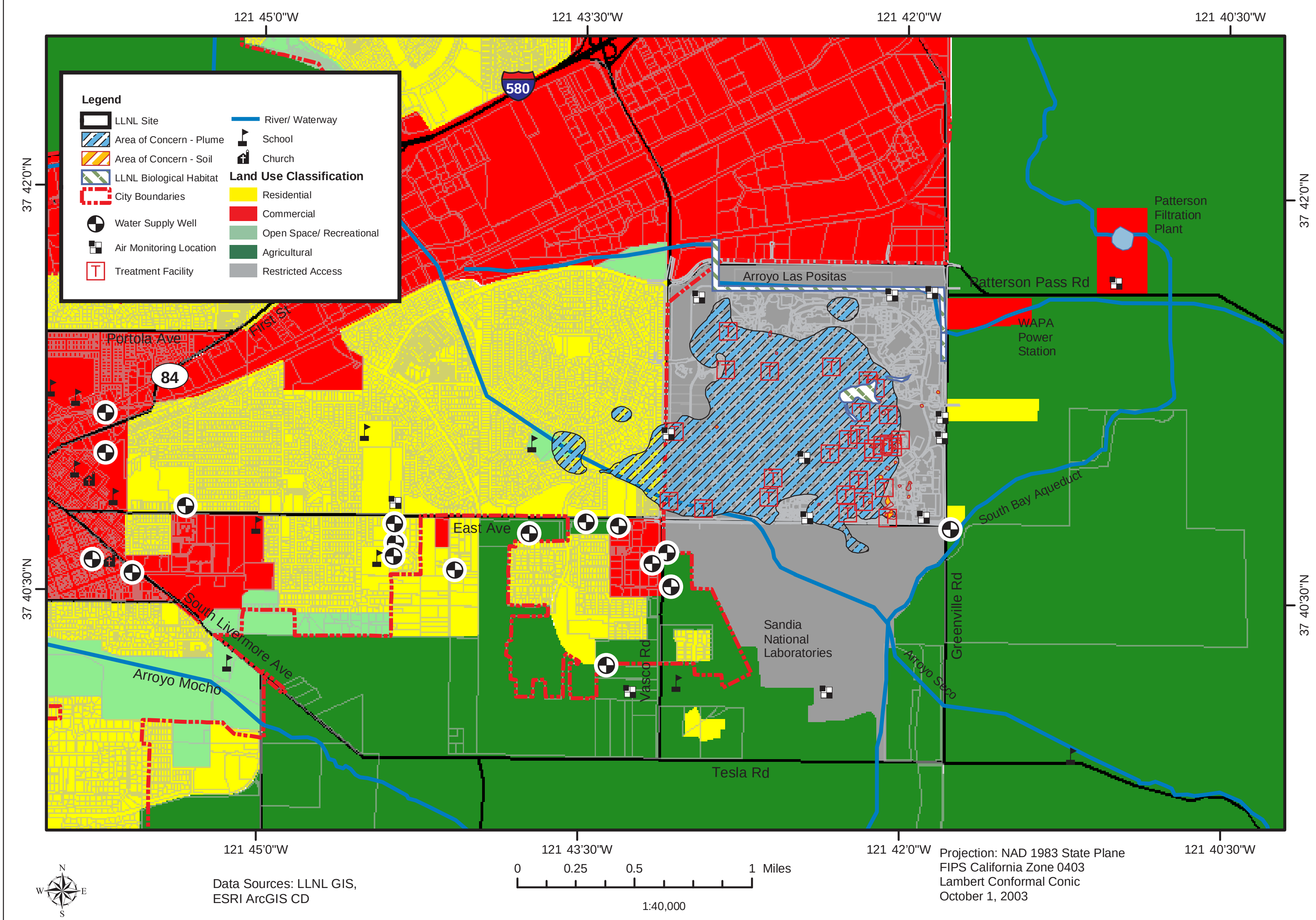
Figure 3.1b. Site Physical and Surface Interface - RBES



Data Sources: LLNL GIS, ESRI ArcGIS CD

Projection: NAD 1983 State Plane FIPS California Zone 0403 Lambert Conformal Conic October 1, 2003

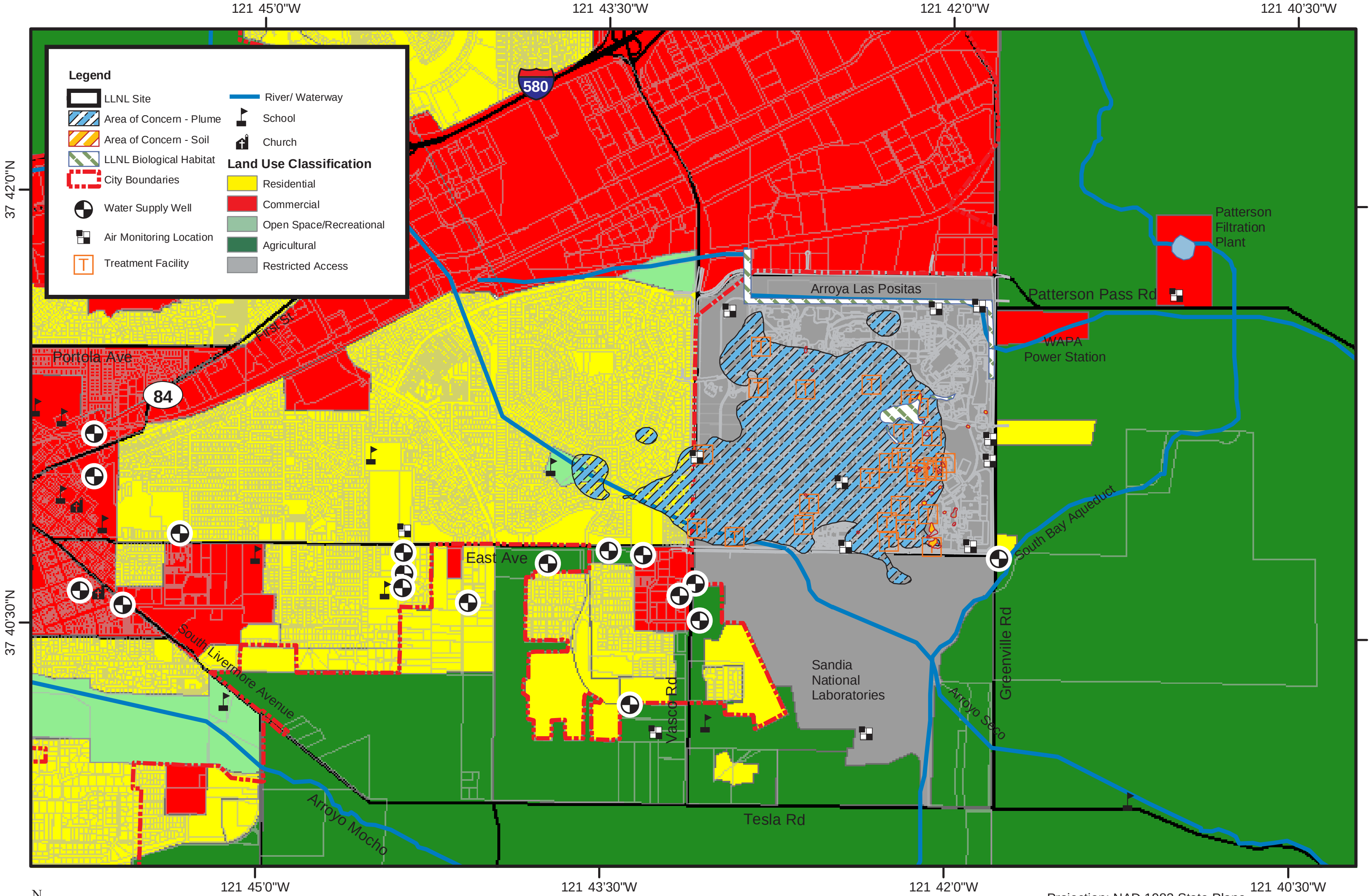
Figure 3.2a. Site Human and Ecological Land Use - Current State



Data Sources: LLNL GIS, ESRI ArcGIS CD

Projection: NAD 1983 State Plane FIPS California Zone 0403 Lambert Conformal Conic October 1, 2003

Figure 3.2b. Site Human and Ecological Land Use - RBES



N
W E
S

Data Sources: LLNL GIS,
ESRI ArcGIS CD

0 0.25 0.5 1 Miles

1:40,000

Projection: NAD 1983 State Plane
FIPS California Zone 0403
Lambert Conformal Conic
October 1, 2003

Figure 3.3a. Site Legal Ownership - Current State

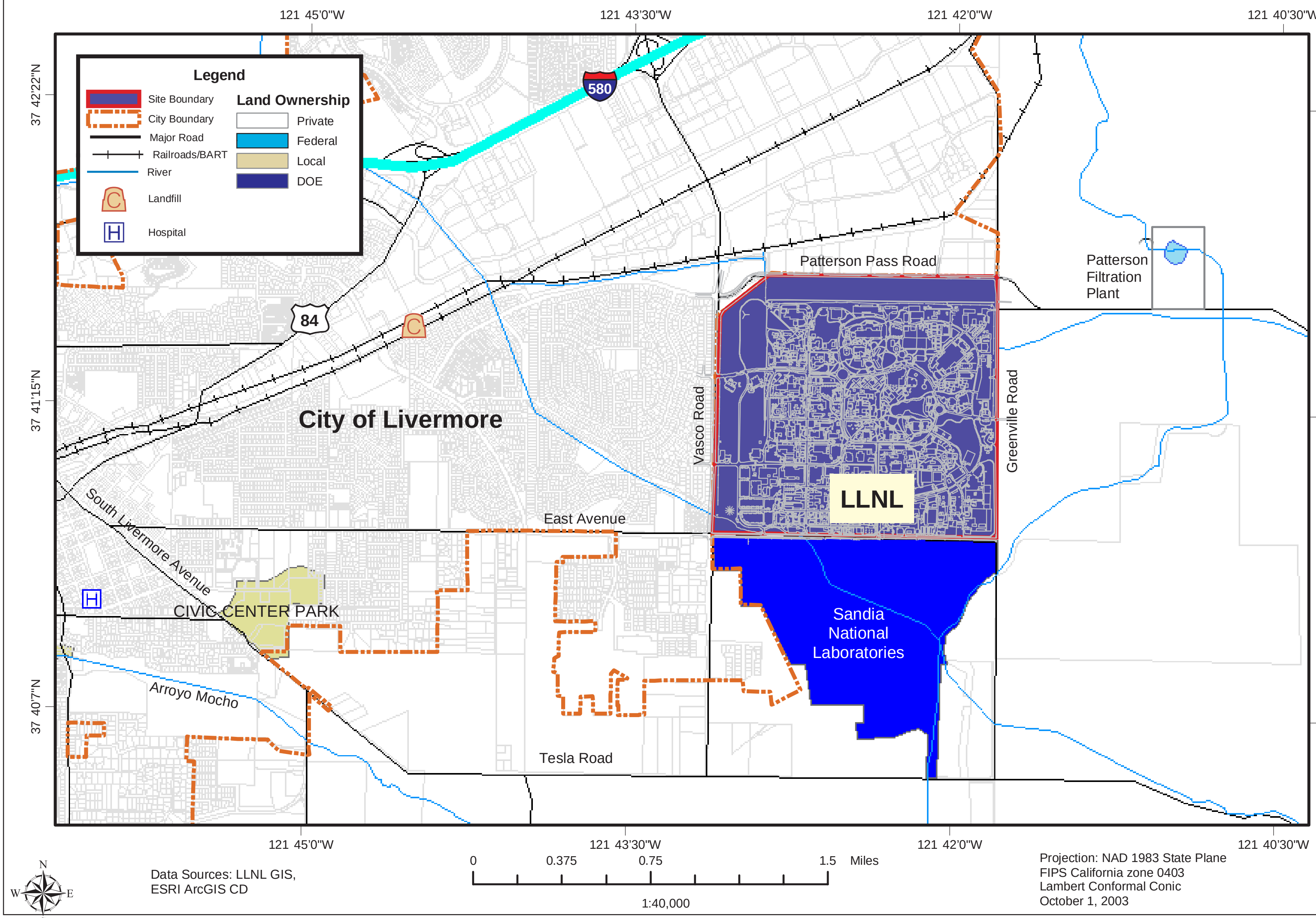
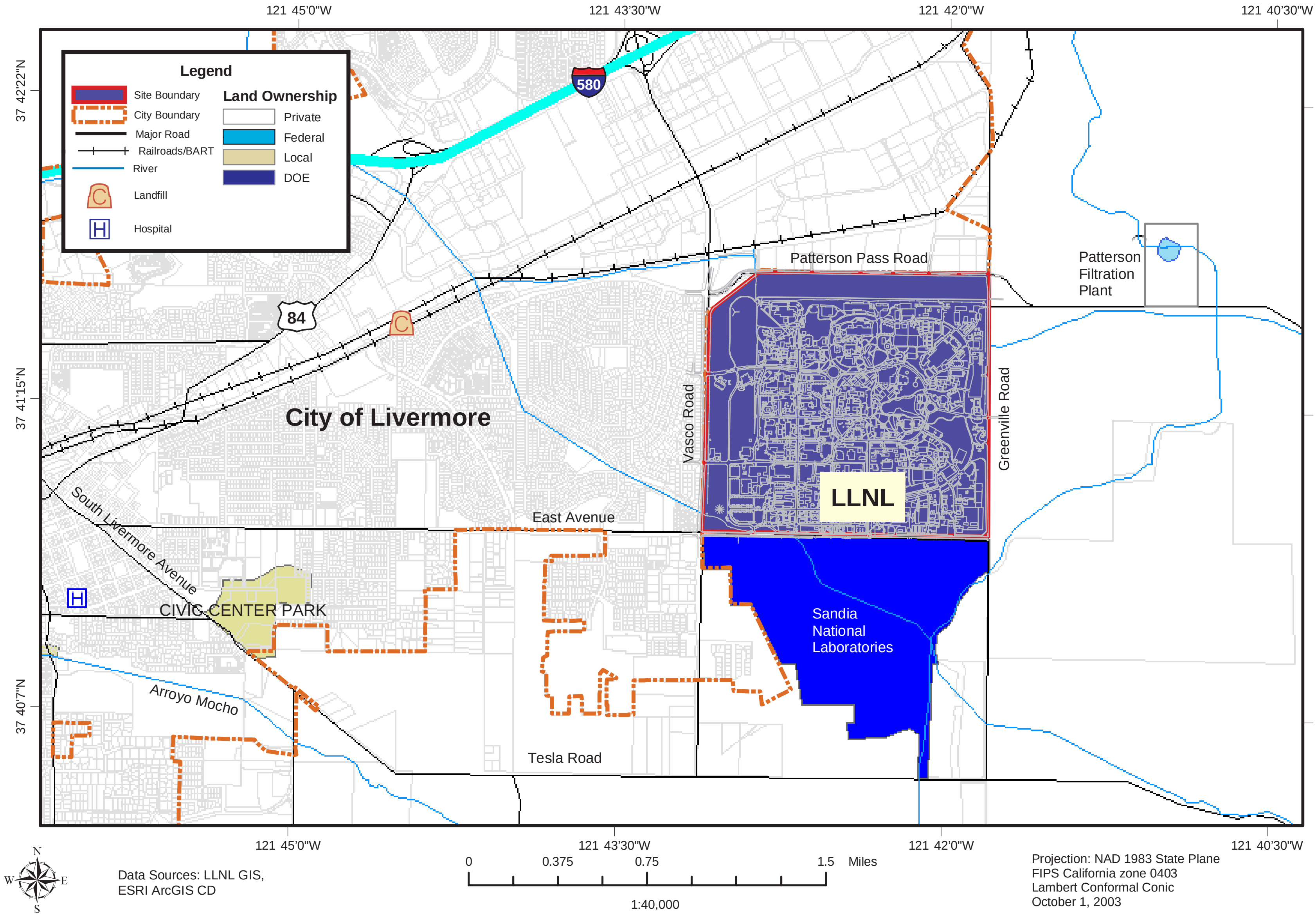


Figure 3.3b. Site Legal Ownership - RBES



Data Sources: LLNL GIS,
ESRI ArcGIS CD

Projection: NAD 1983 State Plane
FIPS California zone 0403
Lambert Conformal Conic
October 1, 2003

Figure 3.4a. Site Demographics - Current State

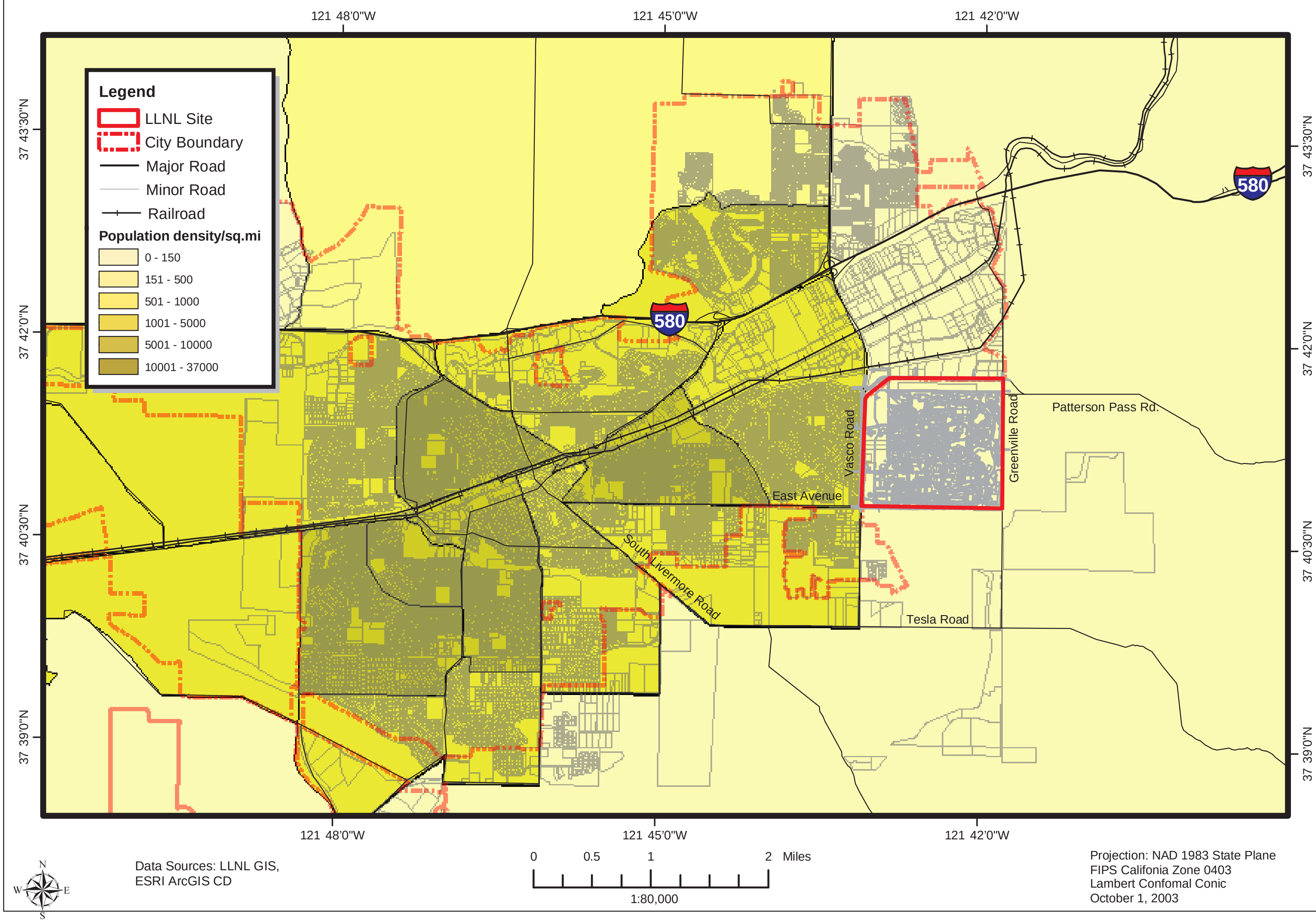


Figure 3.4b. Site Demographics - RBES

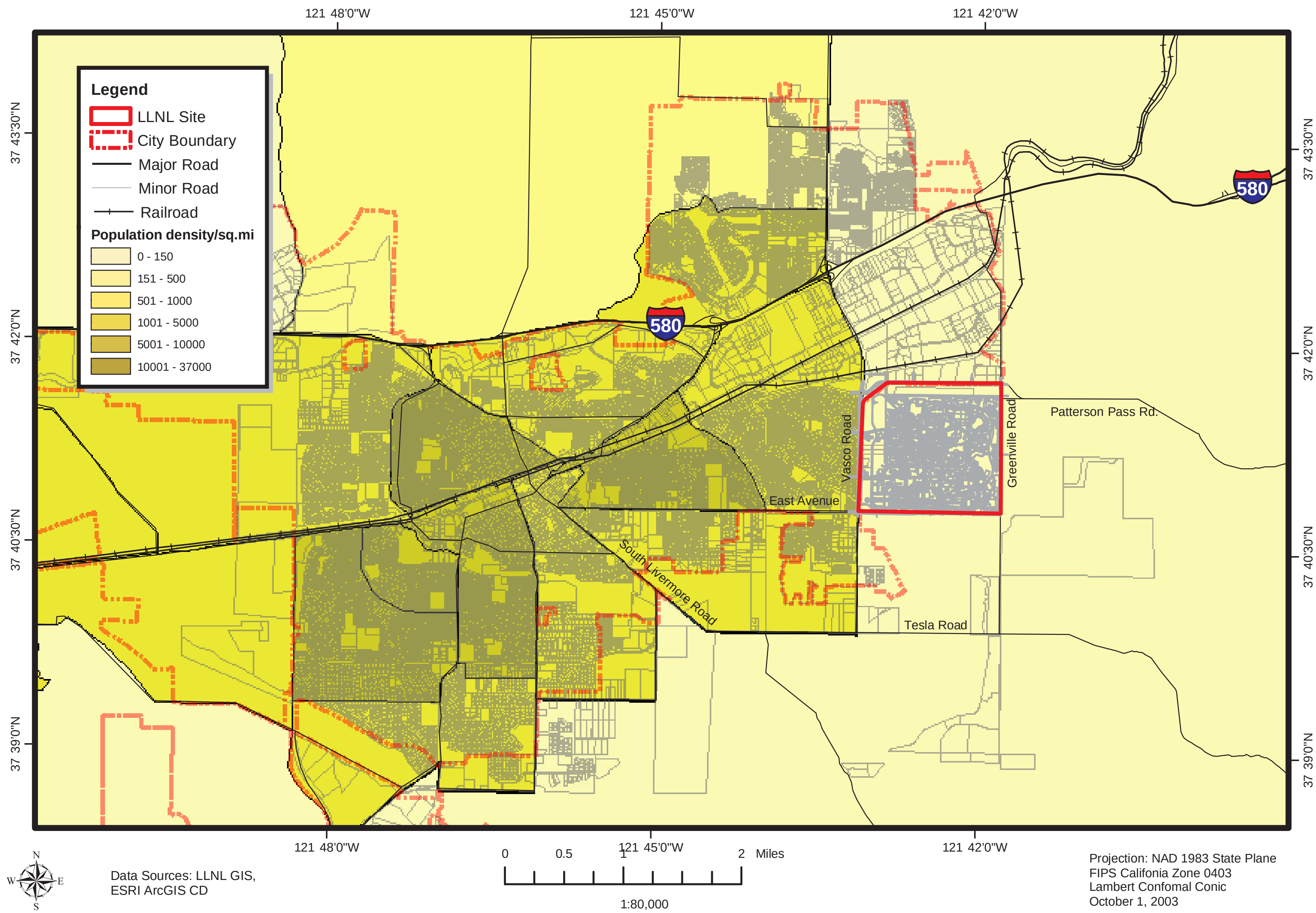
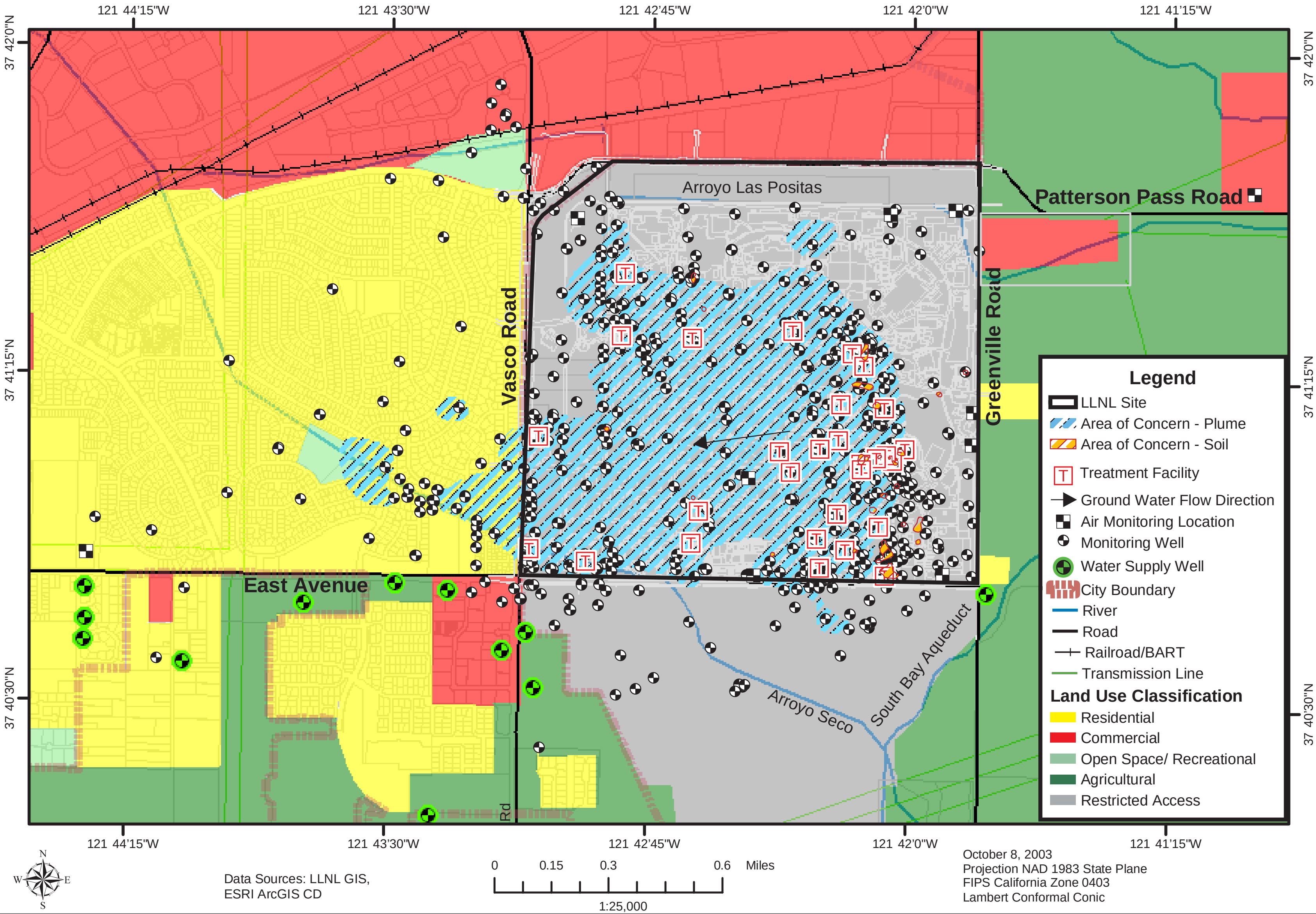
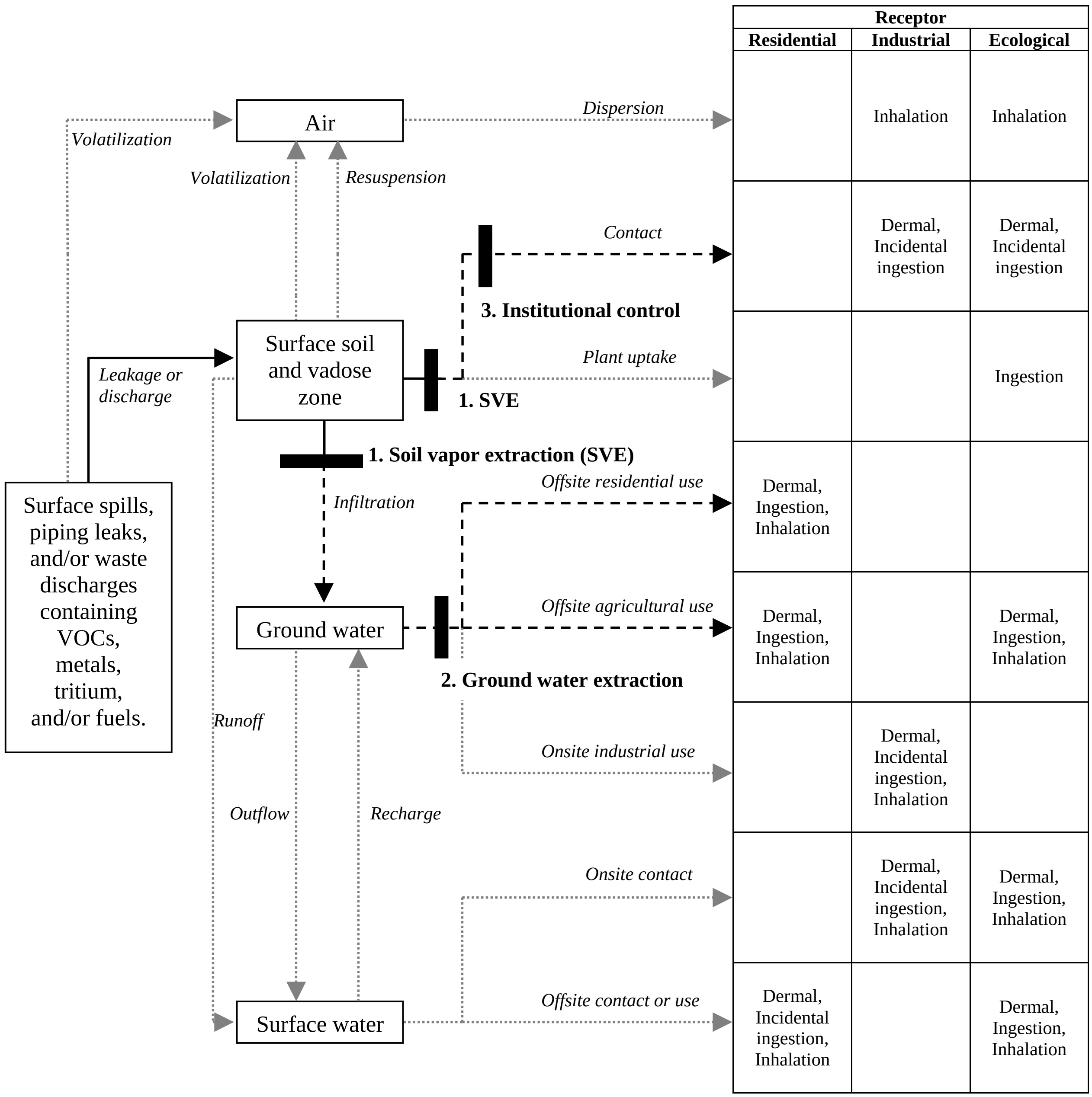


Figure 4.0a. Site-wide Hazard Map - Current State.





<u>Legend</u>

Active transport, uptake, or exposure pathway

Blocked transport, uptake, or exposure pathway

Incomplete pathway

1 Engineered barrier or institutional control, sequentially numbered beginning with the Current State and continuing through the Risk-Based End State

Figure 4.0a2. Site-wide CSM – Current State.

Narrative for Figure 4.0a2: Site-wide CSM – Current State.

Hazard Area Description

Initial hazardous materials releases occurred at the Livermore Site in the mid- to late-1940s when the site was the Livermore Naval Air Station. There is also evidence that localized spills, unlined landfills, and leaking tanks and impoundments contributed VOCs, fuel hydrocarbons, metals, and tritium to the ground water and unsaturated sediments in the post-Navy era. Primary sources include surface spills at facilities, piping leaks, and releases from onsite landfills. Secondary sources include the vadose zone and ground water.

Release, Transport, and Exposure Mechanisms

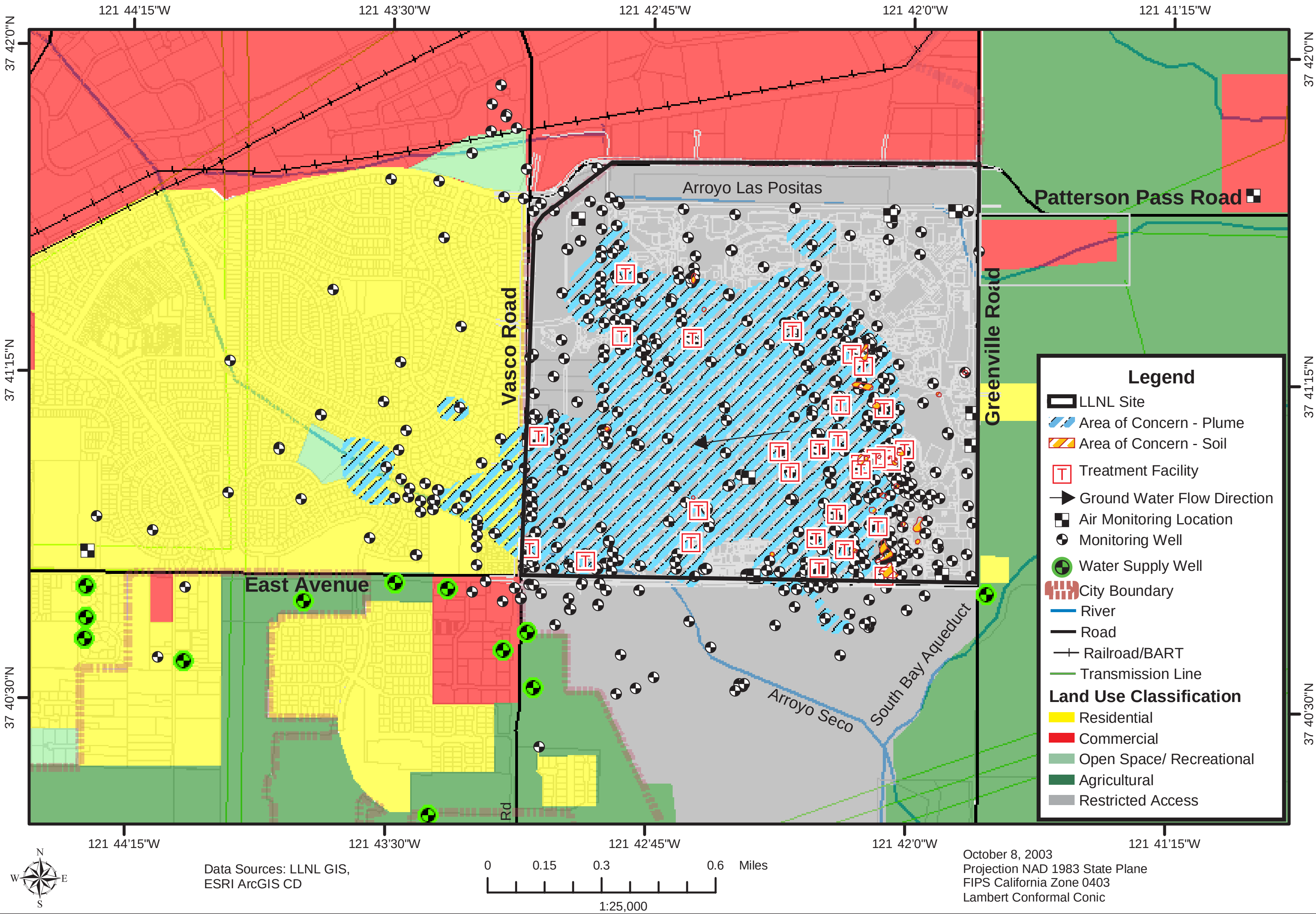
The only release mechanism is leakage or discharge of contaminants to surface soil or the vadose zone. Volatilization of contaminants directly from the released contaminant is not applicable because contaminants have already migrated into environmental media and no active sources remain. Exposure mechanisms include onsite contact with contaminated soil and offsite residential and agricultural use of ground water. The only transport mechanism is infiltration of contaminants from the vadose zone to ground water. Potential receptors include onsite workers and offsite residents.

Remediation and Mitigation

The exposure barriers are numbered sequentially, beginning with the Current State and continuing through the Risk-Based End State. Barriers under the Current State exposure scenario are:

1. Soil vapor extraction (SVE) has been implemented at the Livermore Site to protect ground water from potential or further degradation due to downward migration of contaminants from the vadose zone. Protection of ground water leads to mitigation of risk to onsite and offsite receptors through a ground water exposure pathway.
2. Ground water extraction has been implemented by installing numerous extraction well fields and associated ground water treatment facilities at the Livermore Site. Specifically, removing contaminants from ground water by extraction reduces risk due to: (1) dermal contact, ingestion, and inhalation by offsite human (residential and agricultural) receptors, and (2) dermal contact, ingestion, and inhalation by onsite human (industrial) receptors.
3. The primary institutional control in place at the LLNL Livermore Site is site access restriction.

Figure 4.0b. Site-wide Hazard Map - RBES.



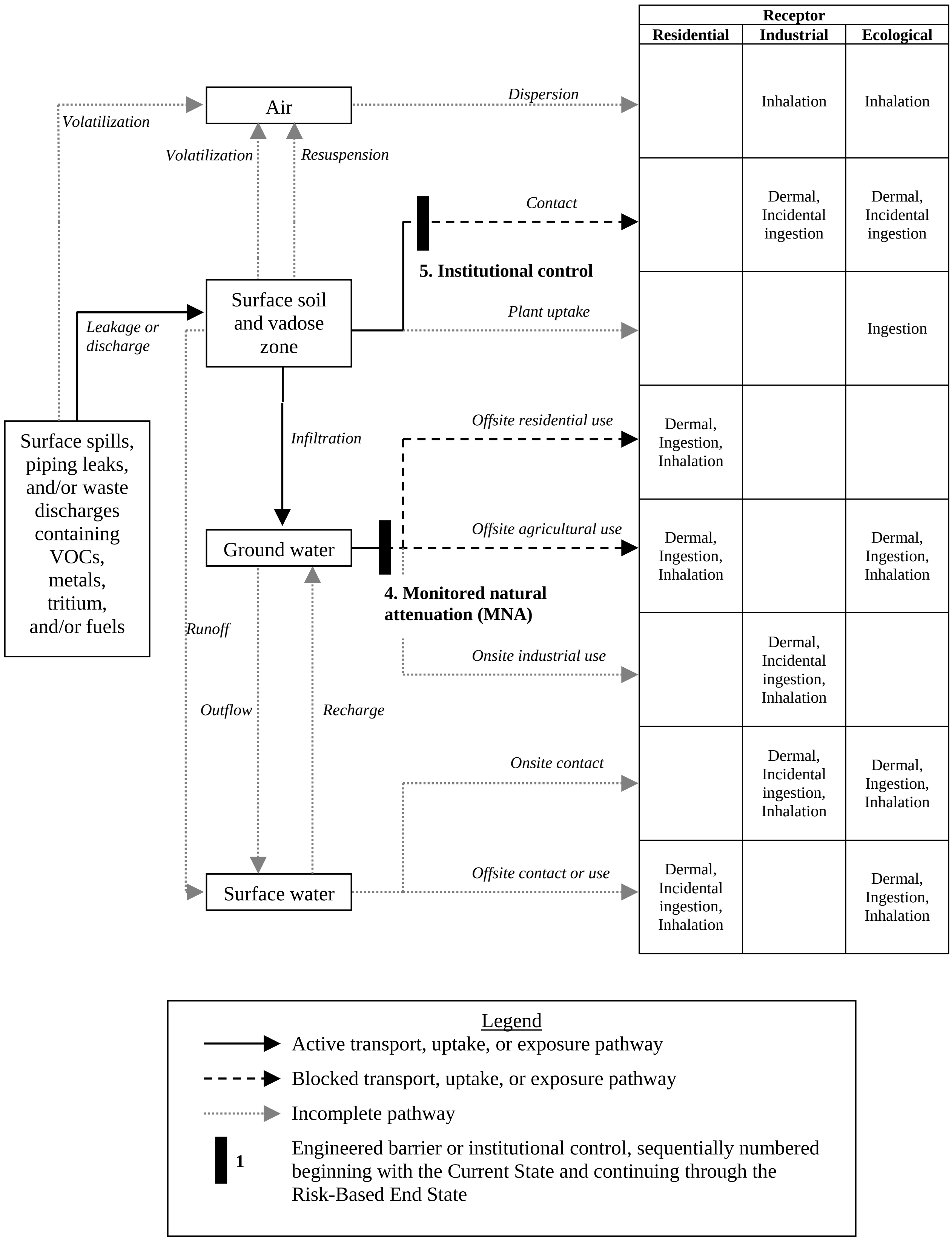


Figure 4.0b2. Site-wide CSM – RBES.

Narrative for Figure 4.0b2: Site-wide CSM – RBES.

Hazard Area Description

Initial hazardous materials releases occurred at the Livermore Site in the mid- to late-1940s when the site was the Livermore Naval Air Station. There is also evidence that localized spills, unlined landfills, and leaking tanks and impoundments contributed VOCs, fuel hydrocarbons, metals, and tritium to the ground water and unsaturated sediments in the post-Navy era. Primary sources include surface spills at facilities, piping leaks, and releases from onsite landfills. Secondary sources include the vadose zone and ground water.

Release, Transport, and Exposure Mechanisms

The only release mechanism is leakage or discharge of contaminants to surface soil or the vadose zone. Volatilization of contaminants directly from the released contaminant is not applicable because contaminants have already migrated into environmental media and no active sources remain. Exposure mechanisms include contact with contaminated soil and offsite residential and agricultural use of ground water. The only transport mechanism is infiltration of contaminants from the vadose zone to ground water. Receptors include onsite workers and offsite residents.

Remediation and Mitigation

The key assumptions relevant to the identification of potential long-term, sustainable barriers for the Risk-Based End State exposure scenario are:

> Ground water remediation being conducted under the Current State exposure scenario has, at some point in the future: (1) achieved the Maximum Contaminant Level (MCL) cleanup standards offsite, and (2) reduced onsite contaminant mass and concentration such that remaining onsite contaminants no longer migrate offsite at concentrations exceeding MCLs. All remaining ground water contamination would be addressed through monitored natural attenuation (MNA). No further ground water extraction would be performed. The point of compliance would be the site boundary.
>
> The State of California agrees that onsite risk-based ground water standards are acceptable, rather than reaching MCLs as specified in the ROD.
>
> Soil vapor extraction conducted under the Current State scenario will have reduced vadose zone contaminant concentrations to levels protective of ground water. No further soil vapor extraction would be performed.
>
> The stakeholders agree that long-term institutional controls are an acceptable risk management measure in lieu of active remediation to levels consistent with unrestricted land use.
>
> LLNL Livermore Site remains under DOE control and has a continuing mission.
>
> There are no unanticipated changes to offsite land use or demographics.

The exposure barriers are numbered sequentially, beginning with the Current State and continuing through the Risk-Based End State. Barriers under the Risk-Based End State exposure scenario are:

4. Monitored natural attenuation would be used to address all remaining ground water contamination.
5. Long-term institutional controls would be maintained under the Risk-Based End State exposure scenario to restrict access to the LLNL Livermore Site and control exposure of onsite workers to contaminants in surface soil (dermal contact and incidental ingestion) by restricting access to specific areas and monitoring potential exposure during construction activities.

Attachment A:
Risk-Based End State Vision Variance Report for Lawrence Livermore National Laboratory Livermore Site

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Risk-Based End State Vision Variance Report for Lawrence Livermore National Laboratory Livermore Site

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Risk-Based End State Vision Variance Report for Lawrence Livermore National Laboratory Livermore Site

This Attachment describes the variances between the Current State and the Risk-Based End State Vision for the LLNL Livermore Site.

Variance 1: Ground Water Compliance Point

Description of Variance:

The Current State assumes that all ground water contaminated by Livermore Site activities must ultimately be remediated to Maximum Contaminant Levels (MCLs), both onsite and offsite. The impacted ground water body is assumed to be the point of compliance.

The Risk-Based End State Vision assumes that the site boundary is the compliance point for contaminants in ground water. This is not consistent with State of California ground water regulations and policies that consider the impacted ground water body to be the point of compliance.

Variance Impacts:

Reducing onsite ground water contaminants to MCLs will require ground water extraction and treatment for a much longer period than would be required to achieve onsite concentrations such that remaining onsite contaminants no longer migrate offsite at concentrations exceeding MCLs. No evaluation has been performed to compare the cost of the Current State to a Risk-based End State.

Barriers to Achieving a Risk-based End State:

The Risk-based End State Vision does not comply with the State Water Resources Control Board's Resolution 92-49 for ground water, which specifies that all polluted ground water be remediated to protect beneficial uses and to restore water quality to background concentrations. If achieving background concentrations is not feasible, cleanup standards must be set at the lowest concentrations that are technologically and economically achievable. The U.S. EPA would have to declare, and the State of California would have to accept, that the State's policies are not Applicable or Relevant and Appropriate Requirements (ARARs) for the cleanup of the Livermore Site. The State requirements are not based on risk but on impact to the quality of waters of the State of California. In 1998, the U.S. Department of Defense invoked formal dispute as to whether these State of California requirements were in fact ARARs. The dispute was decided by the U.S. EPA Administrator in favor of the State of California. The U.S. EPA Region IX office supported the State of California and agreed that Resolution 92-49 and the Basin Plan Narrative Toxicity Standards are ARARs. Interpretation of these ARARs must be determined on a site-specific basis.

It is not likely that the regulatory agencies and other stakeholders would support any remedial strategy that does not result in active ground water cleanup to MCLs, both onsite and offsite.

Recommendations:

Specific recommendations to address this Variance will be developed during preparation of the final Risk-Based End State Vision. Resolution of this issue will likely require EM-1 involvement with State regulators, EPA Region IX, community members, and environmental activist groups.

Variance 2: Ability to Achieve Risk-Based Concentrations

Description of Variance:

It is unlikely that the ground water extraction being implemented under the Current State can adequately reduce contaminant concentrations to levels consistent with the implementation of a Risk-Based End State in the 20-year timeframe considered in this Vision document.

Variance Impacts:

Undetermined. No risk analysis or cost evaluation has been performed to compare the Current State to a Risk-based End State.

Barriers to Achieving a Risk-based End State:

The primary barrier is the technical ability to reduce ground water contaminant concentrations to levels consistent with implementing a risk-based end state in a 20-year time frame. Analysis to determine potential onsite risk-based ground water concentrations has not been performed.

Recommendations:

Specific recommendations will be developed during preparation of the final Risk-Based End State Vision.

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Livermore Site Office
Environmental Stewardship Division
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Livermore, California 94550